The completed Mitchell Gulch Bridge opened to traffic 46 hours after construction began.

COLORADO Lightning Fast Construction at Mitchell Gulch

COLORADO'S SMALL PROJECT HELPS BRING BIG CHANGES

Colorado Department of Transportation (CDOT) Project Manager Tom Hunt summed up the Mitchell Gulch Bridge project as "a small project whose implications for the highway industry may be very large. It gives us another tool in the project delivery toolbox to greatly reduce construction delays. The success of this small project could be part of a paradigm shift in how we do business in the future."

That paradigm has shifted in Colorado, where at least two additional projects have met with success due to lessons learned at Mitchell Gulch. CDOT has also established an Innovative Contracting Branch to capture the best practices of Mitchell Gulch and other projects. The results: better roads and bridges, innovative contracting methods, increased competition, faster construction, safer working conditions, and more value for Colorado's highway dollars. "We constantly look for ways to serve our customers, the traveling public, better," said Hunt. "Getting in and out, getting work done faster, and reducing safety hazards for the public and the construction team are big deals."

The little project at Mitchell Gulch has turned out to be a "big deal" in the highway industry. The lightning fast construction took one weekend with little impact on drivers and within the same cost parameters as standard construction techniques. The project received the National Partnership for Highway Quality 2004 Bronze "Making a Difference" award in the "Breaking the Mold" category for its ground-breaking innovations. Lawrence Construction and Wilson & Company also earned an Engineering Excellence Award from the American Council of Engineering Companies in Colorado and Mitchell Gulch is now featured as a best practice by Highways for LIFE, a Federal Highway Administration program that advances Long lasting highways using Innovative technologies and practices to accomplish Fast construction of Efficient and safe pavements and bridges.

A Catalyst for Change Emerges

The new Mitchell Gulch Bridge, on Colorado's busy Highway 86 in Douglas

County, is located a few miles southeast of the Denver Metropolitan area. Around 12,000 vehicles travel this two-lane road daily, a large percentage during peak commuter hours. Prior to construction, the original bridge was a badly deteriorating timber structure built nearly 50 years earlier and rated as one of the State's 10 worst bridges.

When CDOT requested bids for a box culvert spanning the 40 feet over Mitchell Gulch, it estimated that the relatively standard project would take about two months to complete. Twelve companies bid on the project with the low bidder, Lawrence Construction winning the competition.

Lawrence Construction and the designer, Wilson and Company, had worked closely together on Design-Build (D-B) and Value Engineering (VE) projects in the past, and had already formed a partnership called the "Lawrence Wilson Team." As they peeled back the Mitchell Gulch project, they seized the opportunity to devise a method to replace the structure in a weekend, rather than the projected two months, saving travelers from a dangerous and time consuming detour at a cost in the same ballpark as conventional construction methods.

As a result, the team submitted a Value Engineering Change Proposal (VECP) to CDOT and the game-changing Mitchell Gulch Project was born. Such an ambitious plan had never been undertaken before within CDOT, and the project from the start was under intense scrutiny and curiosity throughout the design and engineering community. The project represented "thinking out of the box" for CDOT; the agency's acceptance of the VECP also made them a key member of the new "Lawrence Wilson CDOT Team."

The new precast, swiftly constructed Mitchell Gulch Bridge is now a reality because of intense, comprehensive planning, the application of new design and construction techniques, and the commitment of a diverse and talented group of professionals who believed in teamwork and partnering. It also stands as a tribute to CDOT as a far-reaching, forward-thinking organization.

Putting It All Together

The Mitchell Gulch Bridge was built with precast substructure units: bridge abutments and wing walls that support the bridge superstructure elements and retain earth fills at the ends of the bridge opening. Also precast: the eight deck girders that serve not only as support elements of the bridge but also as the actual deck of the bridge. In the past, bridge decks have been commonly constructed with cast-in-place concrete techniques, requiring forming and curing times that extend the total construction time for the project. However, using integrated precast substructure/deck units is a unique innovation yielding major benefits to the business of building bridges faster, better, and safer. Since 90 percent of the bridge was made up of precast concrete elements, the work of Plum Creek Structures, the firm providing the precast parts of the bridge, was integral to the success of the project.

The planning sessions for the project resembled military campaign preparations for a big three-day battle. The plan was to reroute Colorado Highway 86 traffic beginning at 7:00 p.m. on Friday, August 23, 2002. Immediately, the old bridge would be dismantled and precast sections would be installed. More than 1200 linear feet of welding would connect the bridge together while a simultaneous operation would rehabilitate the streambed below.

On Saturday afternoon, the precast deck units would be lowered into place, then post-tensioned, welded, and grouted together. Next, earthwork to include

compacting and filling of the approaches would be accomplished, rapidly followed by paving to surface the bridge.

"The planning, coordination, and choreography were intense," according to Mark Scholfield, the Colorado engineering manager for Wilson & Company. Further he noted, "We planned every minute of the project, with numerous contingency plans--including the home phone numbers of materials suppliers and equipment rental firms, just in case. Nothing was left to chance."

The assault began on time, and throughout the weekend, 24-hours per day, one wave of construction troops followed another, according to plan. Demolition of the old bridge took just over five hours. The contractor had already prepared steel H-piles to support the precast substructure ahead of time by driving these 40 feet deep into the stream banks while the original bridge was still in operation. Driving the piles in a geometry that avoided the existing bridge structure was a critical design element that played a key role in allowing the bridge to be built over a weekend.

The weekend replacement of the Mitchell Gulch Bridge begins with demolishing the old wooden structure.

Except for the steel H-pile supports, the rest of the bridge substructure was composed of precast concrete elements. Each abutment was 44 feet wide, consisting of lower and upper back wall units. Each of four, 23-foot long wing walls was a separate precast piece. Welders in the field attached the precast substructure units by welding together embedded plates that were precast into each of the elements.

The bridge superstructure consisted of eight precast deck girder units each 5 feet 4 inches wide, 1 foot 6 inches deep, and 38 feet 4 inches long. The outside deck girders were constructed with integrated bridge railing to avoid the need for a separate railing installation operation in the field, again saving valuable time in the construction process. According to Tom Hunt, "The process of threading together these deck girders was critical because they not only provided support, but represented the actual bridge deck too. It was also important that these elements be leveled in the construction process."

By 1 a.m. on Saturday, August 24th, crews had placed abutments and wing walls in place, and welded them to the steel piles and to each other. All the while, another part of the team was simultaneously placing riprap in an effort to rehabilitate the streambed below. On Saturday afternoon, the team placed flowable fill behind the abutment walls while placing and grouting and transversely post-tensioning the precast girders.

On Sunday morning, August 25th, the crew completed the earthwork and

backfilling, and then asphalt paving of the approach and bridge was begun. All-in-all, the bridge was completed in a record 37 hours of actual construction time in a 46 hour period.

The Inevitable Surprises

The contractor and the engineering manager had orchestrated every minute of the weekend, building in comprehensive contingency plans that left very little to chance. However, surprises and challenges threatened the schedule even before project construction began when a fiber-optic line was unexpectedly discovered in the designed path of the wing walls. The construction team immediately pulled together the experts to adjust the angle of the wing walls to ensure they didn't damage or disrupt the line. Even though this was discovered prior to the beginning of the construction process, the fix couldn't be completed until the road was closed and digging could begin. But this afforded the team the opportunity to problem solve and strengthen teamwork.

More than 90 percent of the Mitchell Gulch Bridge was precast allowing the bridge to be completed over a weekend rather than the planned two-month construction estimate.

On Friday night/early Saturday morning during the construction, the team discovered that some of the precast substructure units did not fit together as expected. The Lawrence Wilson CDOT team solved this problem with the significant on-site welding capability included in the plan; welders were immediately available to execute the solution.

On Saturday evening, an oversight in the deck unit grouting process resulted in unsatisfactory joints, and again Lawrence Wilson CDOT devised field modifications to correct the problem. With bridge construction of this type, the girders become the bridge deck and therefore need to be level and tied together through a post tensioning process. Because this type of post tensioning process is tedious and time consuming, it took more time than was in the plan. In this case, the contractor used epoxy sealer between the girders and began the grouting process prior to the threading being completed. Because the grout set before the post tensioning was complete, some had to be chipped out as the remaining girders were threaded. Again, the team evaluated the issue and came up with a real time solution that kept the project on track.

Innovative Contracting: A Boost from Mitchell Gulch

While Mitchell Gulch was a small project, the large lessons learned from this project and others are now being applied in Colorado in a comprehensive effort to become more efficient and effective. Innovative contracting is a notable example; the new CDOT innovative contracting office was created in part because of Mitchell Gulch.

"The $360,000 Mitchell Gulch and the $1.67 billion Colorado T-Rex Multi Modal Project in Denver were both catalysts that helped us recognize the importance of thinking outside the box," observed Gary Meacham, Branch Manager of the Innovative Contracting Branch in CDOT. In fact, the Innovative Contracting Branch at CDOT, one of the first organizations of its type in the country, was born to capture lessons learned and develop policies and procedures that increase competition, unleash creativity in design, and provide better pricing and value for all projects in Colorado.

"The idea is to build contracting procedures that allow innovation in design, time and cost to be completed up front," noted Meacham. "Give them the project criteria, a blend of descriptive and performance standards, and let the contractor team with the design consultant design the project within the parameters. The result: value for our customers," adds Meacham.

Other Lessons Learned at Mitchell Gulch

One pivotal lesson of Mitchell Gulch is that extensive use of precast concrete bridge elements can save time and money in bridge construction. Precast itself is not new, but precasting 90 percent of a bridge and shrinking the work zone time to one weekend is state-of-the-art. "The success of Mitchell Gulch made CDOT think more about the fast track options for other projects," said Matt Greer, Structural Engineer with FHWA's Colorado Division. "Two additional efforts--Colorado State Highway 6 and US 34 in Big Thompson Canyon, west of Loveland, Colorado--used similar methods very successfully."

Another significant lesson is that planning and coordination promote success in a fast track construction project, especially having a back-up plan to deal with problems that might arise during accelerated construction. Having key people on site during the construction sustained the momentum of Mitchell Gulch.

A third lesson is that things can get chaotic in the short time frame allowed for fast track construction projects, and keeping things moving in the right sequence during execution can be tricky. In the Mitchell Gulch Bridge project, for instance, grouting was begun prior to the completion of post tensioning of the deck girders, resulting in the epoxy setting and having to be chipped out in order to complete the post tensioning process.

According to Greer, a fourth lesson learned is that the construction industry needs to identify additional methods to connect the precast pieces in projects such as this. Mitchell Gulch required long hours of field welding that led to fatigue of the welders. "In a fast-moving project, fatigue issues can lead to safety problems," said Greer, "and identifying new methods of connecting the precast elements might save more time and increase the safety of crews."

A final lesson addresses a challenge to construction designers: how to build a deck without causing future quality problems. With the Mitchell Gulch project, the precast units were post tensioned transversely to lock in the deck and prevent movement between the pieces caused by future truck loads. The problem of

installing the strands occurred when the vertical alignment or camber of the pieces differed between pieces. The lesson learned is that the camber of precast units needs to be monitored in the fabrication yard and provisions such as adding temporary weight could be used to control camber, thus improving the final post tensioning operations.

Prefabricated Bridges and the Future

With the Nation's bridges having a median age of 40 years, and today's increased traffic and urban congestion, accelerated construction methods have become a hot topic. In 2001, the AASHTO Technology Implementation Group (TIG) identified prefabricated bridge elements and systems as one of its innovative technologies. TIG also sponsors workshops and provides speakers for related conferences and other meetings, and publishes a website (http://aashtotig.org) that includes useful information on a number of prefabricated bridge projects.

In addition, FHWA sponsors an Innovative Bridge Research and Construction program that champions prefabrication for accelerated construction. "Our vision is to get out in front of the bridge deterioration curve with accelerated construction such as prefabrication and stay there," said Tom Saad, of the FHWA Resource Center in Chicago in the article "Laying the Groundwork for Fast Bridge Construction" in the November/December 2003 issue of *Public Roads*. "FHWA bridge engineers will partner with States, industry, and academia to develop and implement technologies that produce more durable highway structures that can be constructed in a fraction of the time of conventional structures," explained Saad.

Experience has identified a number of advantages of this type of construction to bridge owners, engineers, builders, and the traveling public:

- Use of prefabricated elements minimizes traffic impacts, and with traffic control running between 20 and 40 percent of construction costs, money is saved and the public is inconvenienced less.

- Contractors can accomplish much of the time consuming work away from the project, in a much safer environment.

- Prefabricated bridges are more easily constructed because of less interference from heavy traffic, especially when working in tight urban work zones. Contractors are able to get in and out quickly with minimal disruption.

- Safety increases with less exposure time on the job for workers.

- Prefabrication and shipment to the job site reduces impacts that occur from onsite fabrication and construction.

Overall quality, lower life cycle costs, accelerated construction, less time in work zones for crews, longer life, and lower cost combine to make this type of construction a winner.

Prefabricated bridge elements, which range today from bent caps to deck panels, and superstructure and substructure systems, are manufactured under controlled conditions and brought to the construction site ready to install. These prefabricated elements are particularly useful in situations where traditional cast-in-place construction would have to be sophisticated and expensive, such as, for example, at long water crossings or complex interchanges.

As Scholfield put it, "The prefabrication technology used at Mitchell Gulch offered numerous advantages, including increased safety and less need for detours…We think the technology is going to continue to increase in popularity."

The Extraordinary Ordinary Bridge

When the project was complete, the people of Douglas County were the proud owners of a new bridge. "It's actually an ordinary bridge," said Wilson & Company's Scholfield, "But the implications of completing it in a weekend and the techniques the team pioneered in doing so are extraordinary. Also, the ability to minimize inconvenience to the traveling public is remarkable, cutting months of detours and delays to mere days."

Douglas Bennett, FHWA's Assistant Division Administrator in Colorado echoed Scholfield's sentiments, "What the team achieved is big even though the project was limited in scope. After it was successfully completed, we asked ourselves why we had not thought of doing this before."

And on Monday morning after the weekend completion of the project, when thousands of commuters headed to work, most probably never realized what had occurred over the previous weekend. They may not have comprehended the magnitude and difficulty of the project that helped make their commute easier. In the eyes of the Mitchell Gulch design and construction team, that's just the way it was planned: for transparency to the public. They strived to prevent the disruption that would have erupted had the project taken the more than two months needed for conventional engineering design and construction.

Thomas Norton, Executive Director of the Colorado Department of Transportation (CDOT) wrote in an Achievement Award to Mr. David Weir of Wilson & Company:

> All of us at CDOT have enjoyed the story of the dismantling and rebuilding of the Mitchell Gulch Bridge on SH 86 in one weekend last August. We have marveled at the precise planning, the teamwork, and the dedication necessary to commit to this sort of concept and to get the job done on time and within budget. I hope this project will serve as a reminder to all of us that with outstanding cooperation, as was demonstrated during this project by Lawrence Construction, Wilson & Company, URS Corporation, Geocal, and CDOT, nearly anything is possible.

Welders attach the substructure of the bridge at Mitchell Gulch.